Working Paper No. 110

Management and Development of Water Resources in the Central Zone

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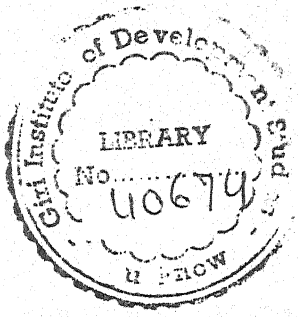

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MANAGEMENT AND DEVELOPMENT OF WATER RESOURCES IN THE CENTRAL ZONE

A.K. Singh*

I. Introduction

Proper husbanding, management and development of natural resources of the nation require the adoption of a regional approach based upon physio-geographic features rather than artificial administrative boundaries. In many cases these natural resource regions would out across state boundaries requiring inter-state coordination as well as some suprastate institution which may reconcile the needs of regional planning and administrative-political set up of the country. It is also evident that the boundaries of resource development regions would also vary according to the particular resource being considered for planning, though in many cases these may be substantially overlapping or even coterminous as in case of multi-purpose river schemes. There is little doubt that Indian planning, hitherto organized on political and administrative boundaries, has to move in the direction of regional planning at all levels - macro, meso and micro - for optimum utilization of the nation's natural resources and their equitous sharing.

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The planning and management of water resources for agricultural and non-agricultural purposes, which must be based on a river basin and watershed approach, provides a most fruitful area where such a regional planning approach can be profitably applied. In the present paper we look at the possibilities and scope for regional planning in the management and development of water resources in the ad hocly defined Central Zone comprising the states of Madhya Pradesh, Bihar, Uttar Pradesh and Rajasthan. The paper also, inter alia, looks at the availability of water resources - both surface and ground - and their present state of utilization and identifies the major issues in planning for the water resources in the region.

II. General Scenario of Water Resources

The states of the Central Zone are large entities in terms of area and population with a combined area of 1,208,000 sq.kms. and population of 26.72 crores. Thus the Central Zone accounts for 36.8 per cent of the country's area and 39 per cent of its population. The density of population is relatively higher in Bihar and U.P., 402 and 377 per sq. km. respectively, as compared to Madhya Pradesh and Rajasthan, 118 and 100 per sq. km. respectively. Though well endowed with natural resources the region is one of the most backward in terms of infrastructural and economic development with a relatively higher concentration of population

below the poverty line. Thus, there is a vast scope for raising income and productivity levels in the region through proper utilization of its large resources with the help of modern technology.

The four states of the Central Zone present a varied picture of physiography and water resource scenario ranging from high hills to plateaus to plains and from humid to arid zones. Though there are significant inter-regional variations in all the four states, in general the water resources are more plentiful in the states of Uttar Pradesh and Bihar lying in the Gangetic basin, as compared to the states of M.P. and Rajasthan.

Rainfall

The climate in the region varies from temperate and humid to sub-humid and arid. Rainfall is fairly adequate in the states of Bihar, M.P. and U.P. all of which receive 1,000 mm or above of annual average precipitation, but it is much lower in Rajasthan - about 700 mm. in eastern parts and only 300 mm. in western parts (Table 1). Against this 600 mm. of annual rainfall is regarded as minimum requirement for cultivation. Nearly 90 per cent of annual rainfall is confined to monsoon period lasting from mid-June to mid-September. The coefficient of variation in annual rainfall is also quite high.

River Systems and Drainage

The states of Rajasthan, U.P. and M.P. form part of the Himalayan drainage system with Ganga as the major river. Madhya Pradesh falls in the peninsular drainage system, though a few peninsular streams like the Chambal, Betwa and Son form part of the Himalayan drainage system. The rivers of the Himalayan system flowing through the Central Zone drain into the Bay of Bengal. The rivers of peninsular Madhya Pradesh follow two district patterns one flowing in the north west direction towards the Arabian Sea (Narmada, Tapti, etc.) and the other in the south eastern direction towards the Bay of Bengal (Mahanadi, Indrawati, etc.) with the Satpuras marking dividing line. The entire Gangetic Plain is criss crossed by numerous streams (Yamuna, Gomti, Ghagra, Gandak, Son, etc.) dividing the land into several big and small doabs. The most important river of Rajasthan plain is the Luni rising in the Aravallis near Ajmer and flowing towards the south west, Sukri and Jawai being its major tributaries. In the southern Aravali highlands of Rajasthan the major stream is the Chambal, which originates from the Vindhyas in M.P.

The perennial rivers of the Himalayan region, fed by melting snows and glaciers, are often uncertain and capricious in their behaviour. They carry heavy silt and are often subject to drastic changes of course. On the other hand, the rivers of

peninsular system, which flow through geographically more stable areas, are more predictable in their behaviour. They are characterized by heavy discharges in the monsoons followed by very low discharges in other months unlike the rivers of the Himalayan system which carry sufficient water even in the lean months.

Ground Water

The Central Zone is also well endowed with plentiful ground water resources though its distribution is unequal over space depending upon geo-physical conditions. The Gangetic plains of U.P. and Bihar are particularly rich in this respect as ground water is available in most parts at a shallow depth of few metres. In M.P. the availability of ground water is relatively restricted as well as more varied. In the pre-Cambrian zone covering Dandakaranya and Bundelkhand region water occurs within 80 m. of surface in the weathered, jointed and fractured zones of the rocks. It is again patchy in the Cuddapah and Vindhyan basins. The deccan trap covering about one-third of the state is a region of poor ground water availability. The Gondwana Sandstones in Godavari basin have good acquifers as also in the alluvium zone in the riverinc tract of the Chambal, Narmada and Tapti. In Rajasthan plains water table is within 50m. of surface in the Luni basin nearer the Aravallis, but sinks rapidly away from Aravallis

along a broad belt across the desert along the Jaisalmer Bikaner axis. Well's more than 100m. deep with uncertain and brackish water supply. Considerable reserves of fresh ground-water have, however, been located in Jaisalmer and Khetri in Rajasthan. In the eastern Rajasthan ground water occurs in the weathered parts of pre-cambrian rocks in the Aravellis and the Cuddapah and Vindhyan basins of sandstone, limestone and slate,

Droughts, Floods and Waterlogging

The concentration of rainfall in the monsoon period, high degree of its variability and prolong dry spells coupled with defective drainage create a number of problems for water managemene in the region. Droughts and floods in many parts are recurrent phenomena. As many as 35 districts of the Central Zone are covered by Drought Prone Area Programme and 11 districts of Rajasthan under Desert Development Programme (Table 2). On the other hand floods are a common problem in the Gangetic plains of eastern U.P. and Bihar. Water logging in the low lying area and along the canals is also a chronic problem affecting an estimated 8.1 lakh hectares in U.P., 3.48 lakh hectares in Rajasthan and 0.57 lakh hectares in M.P. Approximately 29.65 lakh hectares in Central Zone have been affected by serious gullies and ravines - 12.30 lakh hectares in U.P., 6.83 lakh hectares in M.P., 4.52 lakh hectares in Rajasthan and 6.00 lakh

hectares in Bihar. The problem of soil erosion is much more wide spread. Problems of salinity and alkalinity has also developed on a wide scale in the canal irrigated areas. The problem of brackish water is found in the Rajasthan desert.

III. Projected Demand for Water Resources

With the acceleration in the pace of development and increase in population the demand for water resources is likely to shoot up rapidly both for agricultural and non-agricultural uses including industrial and domestic purposes. According to the National Commission on Agriculture 1976 the demand for non-agricultural purposes which was only 8 per cent of total water utilization in 1973-74 is likely to go upto as much as 27 per cent by the year 2025 A.D. During the some period the demand for water was expected to increase by 120 per cent for irrigation purposes (from 35 Mham to 77 Mham), by 833 per-cent for other purposes (from 3 Mham to 28 Mham) and by 176 per-cent for all uses (from 38 Mham to 105 Mham)(1976, pp.9-10).

Similarly one would expect a significant step up in the demand for water in the Central Zone which accounts for nearly 39 per cent of the country's population and 42.5 per cent of its net sown area. According to one estimate the demand for water resources in the Central Zone is likely to go up from 10.5 Mham in 1968 to around 39 Mham in 2000 AD, i.e. by 271 per cent or nearly 8 per cent per annum (Chaturvedi, 1976, p.51).

Statewise projected demand for water use has been shown in Table 3. Thus considerable intensification of use of water resources is expected in the coming years, which underscores the need for efficient and proper management and utilization of our water resources.

IV. Irrigation Potential and Utilization Coverage and Sources

We may now focus on the exploitation of water resources for irrigation purposes. Development of irrigation facilities has been a key component of the strategy of agricultural development in the country and huge funds have been invested in the development of irrigation facilities under the Five Year Plans. Since the beginning of the green revolution there has been a tremendous spurt in the growth of tubewells and pumpsets. Thus the number of electrical pump sets has gone up from 16 thousand in 1960-61 to 15 lakhs in 1984-85 in the Central Zone, while that of diesel pumps has gone up from 23.8 thousand to 15.9 lakhs over the same period.

Still only 30 per cent of net sown area in the Central Zone is under irrigation ranging from 14.0 per cent in M.P. to 57.4 per cent in U.P. (Table 4). The ultimate irrigation potential estimated by the National Commission on Agriculture is much higher around 80 per cent in U.P. and Bihar and around 30 per cent in M.P. and Rajasthan (Table 7). Thus, there is large irrigation potential in all the states of the Central Zone

which needs to be tapped at the earliest.

In the Central Zone as a whole nearly 35 per cent area each is irrigated by canals and tubewells while remaining 30 per cent is irrigated by tanks, wells and other sources. However, the relative importance of different sources varies from state to state (Table 6). Tubewell irrigation is relatively more developed in U.P. and Bihar while canals are more important in M.P. The reliance on other wells is much greater in Rajasthan and M.P., while in Bihar other sources of irrigation still remain significant.

The estimates regarding the ultimate irrigation potential show wide variations. Thus, the Irrigation Commission 1972 estimated total irrigation potential in Central Zone at 36.1 million hectares, the National Commission on Agriculture put this figure at 51.0 million hectares. The current estimates being used by the state governments are still higher. There is, therefore, a clear need to put these estimates on a more firm footing.

The picture with respect to the irrigation potential and its utilization in case of surface and ground water is briefly examined below.

Surface Water

The Irrigation Commission 1972 had estimated the ultimate

irrigation potential of surface water at 24.8 million hectares for the Central Zone - 20.8 million hectares by major and medium projects and 4.0 million hectares in case of minor projects (See Table 6). The National Commission on Agriculture, 1976 revised the figures of ultimate irrigation potential upwards to 29 million hectares (See Table 7). The latest official estimates put the ultimate irrigation potential from major and minor irrigation projects at 27.75 million hectares for the Central Zone, which is approximately 47.5 per cent of the estimated potential of the country (Table 8).

Largest irrigation potential is found in the state of U.P. (12.50 million hectares) and the lowest in Rajasthan (2.75 million hectares), while the ultimate potential is estimated at 6.5 million hectares in Bihar and 6.0 million hectares in M.P. (Table-8). As against this the created potential from major and medium irrigation projects was only 13.3 million hectares for the Central Zone at the end of 1984-85, which is only 47.5 per cent of the ultimate potential. The proportion of irrigation potential created to ultimate potential at the end of 1984-85 came to 65.9 per cent in Rajasthan, 54.5 per cent in U.P., 44.3 per cent in Bihar and only 30.0 per cent in M.P. Even after taking into account the anticipated achievement of the Seventh Plan a large amount of unutilized potential of surface water remains to be exploited. At the same time there

is a significant gap between the potential created and utilized, which is as much as 21.3 per cent for the Central Zone. The per cent of unutilized created potential is 24.6 in Bihar, 27.6 in M.P., 18.5 in Rajasthan and 19.1 per cent in U.P.

Ground Water

Like surface water the estimates of ground water resources have been variously estimated. While the Irrigation Commission 1972 had estimated irrigation potential from ground water at 11.3 million hectares for the Central Zone, the National Commission on Agriculture put the figure at 20 million hectares (Table 7). As per the latest official estimates irrigation potential of ground water resources is 25.7 million hectares for the Central Zone, which is about 47 per cent of the estimated potential of the country (Table 9).

The estimated potential of irrigation from minor schemes has been put at 13.2 million hectares for U.P., 5.9 million hectares for Bihar, 4.2 million hectares for M.P. and 2.4 million hectares for Rajasthan (Table 9). Nearly 75 per cent of the potential from ground water resources has been exploited by 1984-85 in the Central Zone. The extent of exploitation is relatively higher in U.P. (84.8 per cent) and Rajasthan (82.8 per cent) as compared to Bihar (58 per cent) and M.P. (47.4 per cent).

While the figures of the Ministry of Agriculture discussed above reveal a fairly high extent of exploitation of ground water resources, the recent exercises of the Ministry of Water Resources indicate a large unexploited potential of ground water resources. Thus, the present stage of ground water resources development according to the latter source is only 21.59 per cent in the Central Zone - 30.71 per cent in Rajasthan, 28.96 per cent in U.P., 20.90 per cent in Bihar and only 8.20 per cent in Madhya Pradesh (Table 10). This would call for a much more bold strategy for rapid exploitation of ground water resources, which are relatively cheaper, quick yielding and more efficient as compared to the medium and major projects.

V. Strategy for Development and Management of Water Resources

Water is a most precious national resource both for survival and development. Increase in human and livestock population is putting increasingly greater pressure on land and water resources. Development of agriculture as well as industry will be increasingly constrained by the availability of water. Hence the need for proper husbanding, development and management of our water resources cannot be over emphasized. Some of the critical areas from the point of view of the strategy for development and management of the water resources, particularly in the context of the Central Zone, are being highlighted below.

Firstly, there is a need for a more systematic assessment of the water resources-both surface and underground - in different regions of the country so that they can be put on a more firm ground. Along with this studies of projected demand for water for different purposes on a regional basis have to be carried out.

Secondly, the strategy of water use has to be related to the specific situation of a region. In water abundant regions like U.P. and Bihar the aim should be to maximise land productivity through intensive use of water. But in the water scarce regions like M.P. and Rajasthan emphasis has to be on extensive use of water and protective irrigation.

Thirdly, as emphasized by the Irrigation Commission as well as the National Commission on Agriculture comprehensive river basin plans have to be prepared as the river basin, with its defined watershed boundary, is the natural unit for water planning.

Fourthly, in the short run say the next decade, the strategy should be rapid exploitation of the ground water resources, which is more economical, quick yielding and more efficient as compared to medium and large projects, and for which large unexploited potential is available in all the states. Modern technology like remote sensing techniques can be very helpful in location of potential ground water acquifers in the dry regions. On the other hand, in the Gangetic valley

the main concern has to be proper spacing between tubewells and prevention of overdraft by the rich peasants. Liberal credit assistance to small farmers and promotion of community and government tubewells, are needed for more equitable sharing of ground water resources. Working of state tubewells, which has been shown to be abysmal by several studies, needs to be improved.

Fifthly, over the medium and the long run efforts are needed for the exploitation of the surface water resources through minor, medium and large projects. Here the major problems which need attention are those of improper project planning, time and cost over runs, lack of inter-departmental coordination, unutilized irrigation potential, modernisation of old works, absence or poor condition of field channels, inadequate water supply at the tail ends, inadequate returns, low water charges, etc. concertrated efforts to deal with these problems are called for.

Sixthly, efficiency of water use has to be improved through proper water management technique to avoid wastage of water through evaporation and seepage of canal water, absence or poor condition of field channels, over irrigation, adoption of unsuitable cropping patterns, etc. The options to be considered here are lining of canals and channels, chemical and biological methods to reduce evaporation losses,

strengthening and effective maintenance of field channels, proper field levelling, adoption of sprinkle and drip irrigation, rationalisation of water tariffs, propogation of scientific irrigation practices and optimum cropping patterns, etc.

Seventhly, in the dry and arid zones special emphasis has to be placed on water harvesting and conservation of soil moisture. For this purpose planning for land and water resources has to be done on a watershed basis. Renovation of old tanks and other structures in these regions should be taken up on a priority basis.

Eighthly, along with irrigation problems of water logging and drainage have to be taken up as an integral part of water management. Problems of water logging and salinity have emerged on a sizeable scale along the canal banks. In the flat lands of eastern U.P. and north Bihar large tracts remain submerged in water throughout the year. Wrong alignment of road and railway net work also impede the flow of rain water. These problems should receive adequate attention of planners.

Ninthly, the point needs emphasis that land and water resources are interrelated in a dynamic natural setting and have to be planned together. The problems of deforestation, soil erosion, sedimentation of reservoirs, floods, water logging, soil salinity, etc. are closely interrelated. Thus, an integrated approach to management of our land and water

resources has to be adopted. This would require a high degree of coordination among various concerned department and doing away with the highly departmentalised approach in existence today.

Finally, no official programme of management of our land and water resources can hope to succeed without the close involvement and participation of the people within a decentralised decision making framework. Hence, the community approach, for which a long tradition exists in the country, has to be encouraged in the management of our land and water resources and people's participation in programme formulation, implementation and management has to be ensured.

VI. Need and Scope of Regional Approach to Water Resource Planning

In the beginning we have emphasized the need of a regional approach for the optimum utilization of the nation's natural resources and pointed out that such an approach is particularly advisable in the case of development of the water resources. We can draw lessons from the Soviet planners in this regard, who have utilized water resources and hydropower for region forming purposes and developing specialized territorial production complexes (Alam and Kidwai, 1987). The Soviet experts have also recommended such a regional approach to the development of India's water resources. In the Indian

case the need for inter-state coordination or adoption of a zonal approach specially arises because while development of water resources is a state subject most of our rivers flow through several states. Inter-state disputes have prevented fuller and equitable utilization of our water resources. As much as 20 million hectare of irrigation potential is locked up in legal wrangles capable of producing an additional 34 million tons of foodgrains (Alam and Kidwai, p.101).

Though there are a number of river basins (e.g. Narmada, Tapi, Mahi, Luni, Sabarmati, etc.) for which coordination is needed with states falling outside the Central Zone as defined for the purpose of this paper, there is considerable scope for regional approach for development of water resources in the zone. Several rivers forming part of the Ganges basin (with the exception of river Mahi) pass through two or more of the states constituting the central zone (Map 1). Table 11 shows the catchment area, annual run off and hydro-power potential of these rivers. The combined catchment area of these rivers is 7,66,649 sq. kms. and the annual run off 4,39,568 M.Cu.M. as per the Report of The Irrigation Commission 1972. The hydel power potential of these river systems is estimated at 12,880 MW and surface water potential at 16.03 M.Ha.M. Fortunately the inter-state water disputes in the zone are not as acute as in case of the rivers of the southern zone.

A number of inter-state multi-purpose and major irrigation projects have either been completed or are in various stages of progress (Table 12). This raises hopes for increased cooperation in water resource development in the central zone.

The need for preparing river basin plans was recognized as early as in the fifties and the River Boards Act was passed in 1956 empowering the Union Government to establish river boards to advise the concerned state governments on the regulation and development of inter-state rivers. The Irrigation Commission 1972 also suggested the creation of river basin commissions. The proposal received endorsement from the National Commission on Agriculture 1976 and has been reiterated by the National Water Policy Statement of 1988. However, no concrete steps were taken in this direction and the Union Government preferred to resort to adjudication under the Inter-State River Dispute Act in certain cases. As has been pointed out by scholars tribunals and other judicial bodies cannot be a substitute for a continuous body with necessary autonomy, authority and expertise as river basin commissions (Vaidyanathan, 1990, pp.10-11).

The region also offers possibilities of reducing inter and intra-regional disparities in water resource availability by transferring water from surplus basins to deficit basins. Scholars have pointed out the technological possibilities for such inter basin water transfers (Chaturvedi, 1976 and 1985;

Rao 1976). According to the scheme suggested by Rao 17,000 cumecs of monsoon flow would be pumped up the river Son to the river Narbada, part of which would be used for scarcity areas in the South Ganges basins and the rest will be transferred through the Narbada to the west flowing rivers like Sabarmati, Mahi, Narbada and Tapti (Table 13 and Map 2). The National Perspective for water resource development prepared by the Ministry of irrigation also advocates interlinking of major rivers and development of available storage sites wherever possible. Narbada has a large storage potential, where surface water of the Ganga basin can be stored. Such inter-basin links can also be developed by linking the southern tributaries of the Yamuna like the Ken, Dhasan, Betwa, Sindh and Chambal.

Efforts should be made to move towards a national water grid by giving these visions a concrete shape after a through study of the technological, economic, ecological and organisational considerations involved. The optimum development of our water resources along these lines opens up tremendous possibilities for promoting economic development and employment generation. As emphasized earlier inter-state cooperation and adoption of a regional approach are necessary preconditions for the optimum utilization of our water resources.

Table 1 : Annual Rainfall in Metereological Divisions of Central Zone (in mm).

Division	Normal Rainfall	Actual Rainfall	
		1984-85	1985-86
Bihar Plateau	1349	1143	1028
Bihar Plains	1214	1271	1075
East Uttar Pradesh	1023	998	1064
Plain of West U.P.	917	859	830
Hills of West U.P.	1513	1972	1472
West Rajasthan	335	201	210
East Rajasthan	706	415	674
West M.P.	1023	868	1181
East M.P.	1350	1177	1225

Source : Indian Agriculture in Brief, 21st Edition

Table 2 : Districts Covered Under the Drought Prone Area Programme

State	No. of Districts	Name of Districts
Bihar	5	Monghyr, Nawadah, Palamau, Rohtas, Santhal Parganas.
Madhya Pradesh	6	Betul, Dhar, Jhabua, Khargond, Shahdol, Sidhi.
Rajasthan*	8	Ajmer, Banswara, Dungarpur, Jhalawar, Kota, Sawai, Madhopur, Udaipur, Tonk.
Uttar Pradesh	16	Almora, Allahabad, Banda, Bahraich, Chamoli, Gonda, Hamirpur, Jhansi, Lalitpur, Lakhimpur Kheri, Mirzapur, Pithoragarh, Pauri Garhwal, Tehri Garhwal, Sitapur, Jalaun.

*In addition 11 districts of Rajasthan are covered under Desert Development Projects, namely, Barmer, Bikaner, Churu, Sriganganagar, Jaisalmer, Jalore, Jhunjhunu, Jodhpur, Nagaur, Pali and Sikar.

Source : Indian Agriculture in Brief, 21st Edition.

Table 3 : Projected Water Demand in Central Zone (M.HaM).

State	1968	2000	Present Increase
Uttar Pradesh	4	18	350
Bihar	2	9	350
Rajasthan	3	6	100
Madhya Pradesh	1.5	6	300
Central Zone	10.5	39	271

Source : M.C. Chaturvedi, Water : Second India Studies, MacMillan India, Delhi, 1976, p.51.

Table 4 : Net and Gross Irrigation Area in Central Zone, 1982-83.

('000 hect.)

State	Net Irrigated Area		Gross Irrigated Area	
	Actual	% to NSA	Actual	% to GSA
Bihar	2319	28.0	3350	34.7
Madhya Pradesh	2656	14.0	2744	12.4
Rajasthan	3218	20.5	4088	22.2
Uttar Pradesh	9884	57.4	12125	49.1
Central Zone	18077	30.0	22307	29.8
India	39969	28.2	52029	30.1

Source : Indian Agriculture in Brief, 21st Edition

Table 5 : Net Irrigated Area by Sources in Central Zone, 1982-83.

('000 hect.)

State	Canals	Tanks	Tubewells	Other wells	Other Sources	Net Irrigated Area
Bihar	914 (39.4)	94 (4.1)	689 (29.7)	166 (7.2)	456 (19.7)	2319 (100.00)
Madhya Pradesh	1161 (43.7)	186 (7.0)	52 (2.0)	1071 (40.3)	186 (7.0)	2656 (100.00)
Rajasthan	1025 (31.9)	143 (4.4)	167 (5.2)	1830 (56.9)	53 (1.6)	3218 (100.00)
Uttar Pradesh	3327 (33.7)	167 (1.7)	5379 (54.4)	692 (7.0)	319 (3.2)	9884 (100.00)
Central Zone	6427 (35.6)	590 (3.3)	6287 (34.8)	3759 (20.8)	1014 (5.6)	18077 (100.00)

Note : Figures in parentheses show per cent to net irrigated area.

Source : Indian Agriculture in Brief, 21 Edition.

Table 6 : Ultimate Irrigation Potential (Million Hectares)

State	Major & Medium Projects	Minor Projects		Total
		Surface Water	Ground Water	
Bihar	4.4	1.8	1.8	8.0
Madhya Pradesh	5.6	0.8	1.6	8.0
Rajasthan	3.2	0.4	1.4	5.0
Uttar Pradesh	7.6	1.0	6.5	15.1
Total Central Zone	20.8	4.0	11.3	36.1
Total India	45.5	14.0	22.2	81.7

Source : Report of the Irrigation Commission, 1972, Government of India, New Delhi, Vol.I, pp.218-219.

Table 7 : Ultimate Irrigation Potential 2025 (Million Hectares)

State	Total	Surface Water	Ground Water	Total as % of GAS
Bihar	13.1	9.0	9.1	82
Madhya Pradesh	9.1	6.1	3.0	32
Rajasthan	4.8	2.9	1.9	31
Uttar Pradesh	24.0	11.0	13.0	84
Central Zone	51.0	29.0	22.0	58
India	110.0	70.0	40.0	52

Source : Report of the National Commission on Agriculture, 1976, Part V, Resource Development, pp.44-45.

Table 8 : Benefits from Major and Medium Irrigation Schemes till 1984-85.

(Thousand Hectares Gross)

State/Union Territory	Ultimate Irrigation Potential	Irrigation Benefits at the end of 1984-85		Targets of Additional Benefits during 7th Plan	
		Potential	Utilisation	Potential	Utilisation
Bihar	6500	2879	2176	315	500
Madhya Pradesh	6000	1802	1305	380	370
Uttar Pradesh	12500	6813	5513	637	600
Rajasthan	2750	1812	1476	390	250
Central Zone	27750	13306	10470	1722	1720
All India	58475	30497	25319	4297	3906

Source : Indian Agriculture in Brief, 21st Edition.

Table 9 : Benefits from Minor Irrigation Schemes (1979-80 to 1985-86)

(Thousand Hectares)

States	Ultimate Potential	Potential created at the end of 1984-85	Potential Utilised at the end of 1984-85	Targets of Additional Benefits During 1985-90	
				Potential	Utilisation
Bihar	5900	3422	3150	1140	840
Madhya Pradesh	4200	1992	1870	700	525
Rajasthan	2400	1987	1937	180	130
Uttar Pradesh	13200	11990	10977	3600	2480
Central Zone	25700	19391	17934	5620	3975
All India	54927	37378	35143	8585	6246

Source : Indian Agriculture in Brief, 21st Edition.

Table 10 : Ground Water Resource Potential (M HaM/Yr)

State	Utilizable Net Draft Resource		Potential Available for Future Development	Stage of Ground Water Development (%)
Bihar	2.8566	0.5969	2.2597	20.90
Madhya Pradesh	5.9468	0.4875	5.4593	8.20
Rajasthan	1.4571	0.4474	1.0097	30.71
Uttar Pradesh	9.2683	2.6840	6.5843	28.96
Central Zone	19.5288	4.2158	15.3130	21.59
India	41.8538	9.9942	31.8596	23.88

Source : Ministry of Water Resources, Government of India, Ground Water Development of India, 1986

Table 11 : Basin-wise Catchment Area and Water and Hydel Resources in Central Zone.

River Basin	Catchment Area (Sq.Km)						Average Annual Run Off M.Cu.M.	Hydro Power Potential at 60% Load Power Mw	Ultimate Utilisable Surface Water Potential M.Ha.M
	Bihar	U.P.	M.P.	Rajas-than	Other states	Total			
Chambal	-	850	57948	80670	-	139468	24312	232	1.80
Yamuna (excluding Chambal)	-	73763	81030	31820	40142	226755	65621	1004	1.43
Tons, Karamnasa and Others between Yamuna & Son	5332	10909	12328	-	-	28569	-	90	1.04
Gomti, Ghagra, and other rivers between them	3000	98127	-	-	-	101127	122793	4587	2.66
Son	17651	5952	47656	-	-	71259	42308	554	3.13
Gandak and other left bank tributaries	47535	968	-	-	8795	57298	134277	4788	3.77
Ganga	9182	71302	-	-	26847	107331	42555	1592	1.33
Mahi	-	-	6695	16453	11694	34842	7702	33	0.87
Total	82700	261871	205657	128943	87478	766649	439568	12880	16.03

Source : Compiled from the Report of The Irrigation Commission, 1972.

Table 12 : Inter-State Multi-purpose and Major Irrigation Projects Continuing From Earlier Plans Into Seventh Five Year Plan in Central Zone.

State/Scheme	Plan in which started	Estimated Cost (Rs. Crores)	Ultimate Benefit ('000 ha.)
Bihar			
1. Subarnarekha	V	665.20	209.30
2. Bansagar	V	64.23	N.A.
Madhya Pradesh			
1. Rajghat	V	212.35	97.20
2. Bansagar	V	479.61	249.00
3. Urmil	V	6.33	7.70
4. Kalisarar	V	2.42	1.20
5. Bawanthadi	VI	127.81	18.60
Rajasthan			
1. Gurgaon Canal	III	13.92	28.20
2. Mahi Bajaj Sagar	IV	215.92	80.00
3. Narmada Sardar Sarovar	VI	347.72	N.A.
Uttar Pradesh			
1. New Okhla Barrage	V	39.00	-
2. Rajghat	V	125.21	142.00
3. Bansagar	V	192.76	134.00
4. Urmil Dam	V	13.98	4.77
5. New Tajewala Barrage	V	20.00	-

Source : Indian Agriculture in Brief, 21st Edition.

Table 13 : Zonal Distribution of Land-Water Resources

Zone No.	Total water (annual discharge 10^9 m^3)	Percentage of land cultivated	Water potential (% of total)	Proposed interbasin links
1. Indus, Brahmaputra and Ganga (North Zone)	1045	44	77	Brahmaputra-Ganga Ganga-Narbada
2. Sabarmati, Mahi, Narmada and Tapti (West-flowing)	70	19	5	Ganga to Narbada and to others
3. Sabarnarnarekha, Brahmani, Baitarni, Mahanadi, Godavari, and Cauveri (East-flowing)	195	35	14	From northern rivers of the region to southern rivers
4. West-flowing rivers in Kerala	40	2	3	To be transferred to the East
Total	1350	100	99	

Source : Rao 1978

References

1. S. Manzoor Alam and Atiya Habeeb-Kidwai (eds.) Regional Imperatives in Utilisation and Management of Resources : India and the USSR, Concept Publishing Co., New Delhi, 1987.

2. M.C. Chaturvedi, Second India Studies - Water, MacMillan Co. of India, Delhi, 1976.

3. M.C. Chaturvedi and Peter Rogers (eds.), Water Resources Systems Planning : Some Cases Studies for India, Indian Academy of Sciences, Bangalore, 1985.

4. B.D. Dhawan, "Water Resource Management in India : Issues and Dimensions", Indian Journal of Agricultural Economics, Vol.44, No.3, July-September 1989.

5. Government of India, Report of the Irrigation Commission 1972, New Delhi.

6. Government of India, Report of the National Commission on Agriculture 1976, New Delhi

7. J.S. Kanwar (ed.), Water Management - The Key to Developing Agriculture, Agricole Publishing Academy, New Delhi, 1988

8. K.L. Rao, India's Water Wealth, Orient Longmans, New Delhi, 1976.

9. K.L. Rao, "River Interlinks for Irrigation in India", Hindustan Times, April 8, 1978.

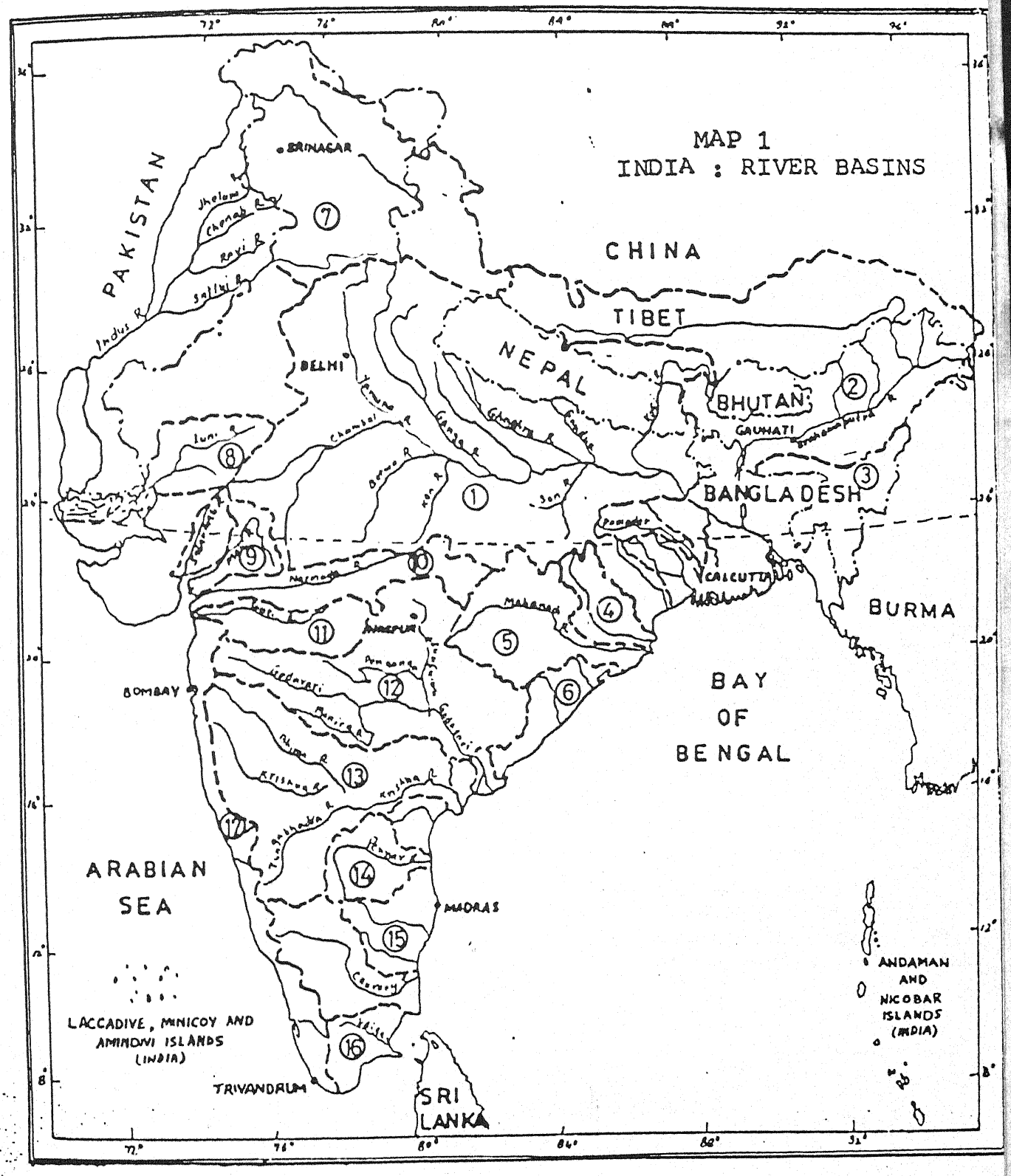
10. S.D. Sawant, "Irrigation and Water Use", in M.L.Dantwala etc. al, Indian Agricultural Development Since Independence, Oxford and IBH Publishing Co., New Delhi, 12188.

11. A.N. Sharma and Shaibal Gupta (ed.), Bihar - Stagnation or Growth, Spectrum Publishing House, Patna, 1987.

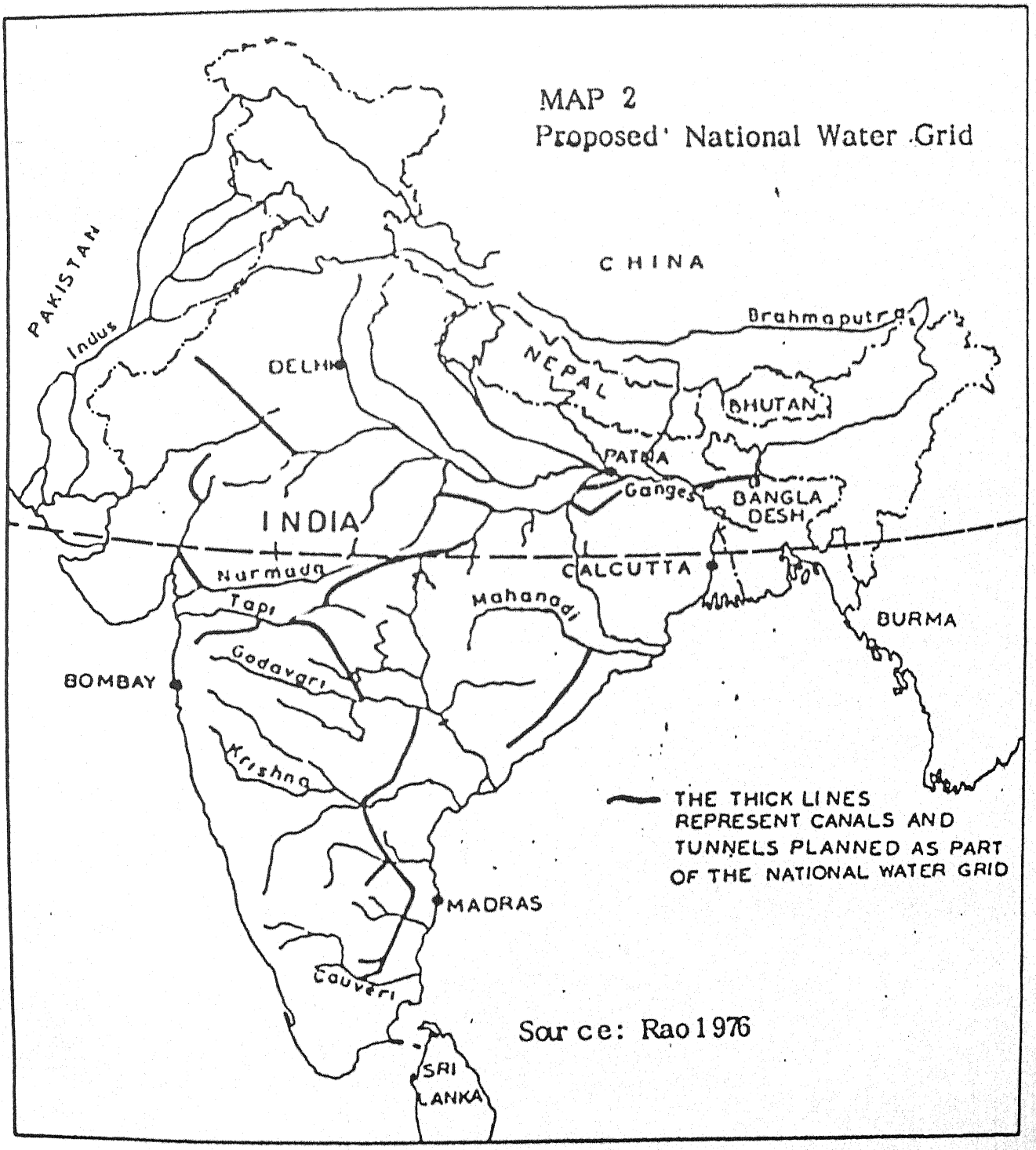
12. Ajit Kumar Singh, Agricultural Development and Rural Poverty, Ashish Publishing House, New Delhi, 1987.

13. R.L. Singh (ed.), India : A Regional Geography, National Geographical Society of India, Varanasi, 1971.

14. A. Vaidyanathan, "Approach to Zonal Planning for Water in South India", in Malcolm S. Adisheshia (ed.), Planning Perspectives of the Southern Zone, Lancer International, New Delhi, 1990.



India—: river basins 1) Ganga, 2) Brahmaputra, 3) Barak & others 4) Between Ganga & Mahanadi (east-flow), 5) Mahanadi, 6) Between Mahanadi & Godavari (east-flow) 7) Indus, 8) Luni & others, 9) Sabarmati & Mahi, 10) Narmada, 11) Tapi, 12) Godavari 13) Krishna, 14) Pennar & others, 15) Cauvery, 16) Below Cauvery (east-flow), 17) Below Tapi (west-flow). International boundary—·—, river basin boundary——— (source: Chaturvedi 1976


MAP 2
Proposed National Water Grid
PAKISTAN
Indus
CHINA
Brahmaputra
DELHI
NEPAL
BHUTAN
PATNA
Ganges
BANGLA DESH
INDIA
Narmada
Tapi
CALCUTTA
Mahanadi
BURMA
Godavari
BOMBAY
Krishna
THE THICK LINES REPRESENT CANALS AND TUNNELS PLANNED AS PART OF THE NATIONAL WATER GRID
MADRAS
Cauveri
SRI LANKA
Source: Rao 1976